Large Oscillating Water-Sediment Tunnel

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LONG-TERM GOAL

The U.S. Navy's mine warfare community needs reliable predictive capabilities for mine burial in shallow water environments. Currently, there are no experimental facilities in the U.S. with the capabilities needed to carry out laboratory experiments on mine burial processes at full scale. The main goal of this effort is the construction of such a facility so that tests can performed in the laboratory but under conditions representative

OBJECTIVES

The main objectives of this effort are to study: a) fluid forces on model mines and sediments, b) stability of the sediment-mine system in a bottom boundary layer produced by an oscillatory flow and currents, and c) mine burial due to sediment scour.

DESCRIPTION OF LOWST AND ITS APPLICATIONS

The Large Oscillating Water-Sediment Tunnel (LOWST) is a U-shaped tube, with one open leg and with three pistons located in the other leg to generate a horizontal oscillatory flow in the test section. This unique facility has been designed to reproduce in the laboratory combined wave-current flow near the seabed. Important advantages of LOWST are the facts that flow velocities will be simulated at full scale and that a net current can be superimposed on the oscillatory flow. Sediment can be placed along the 12.5-m-long wave-current duct, which has a 60-cm-deep movable-bed to facilitate the study of flow-induced scour and sedimentation around structures (Figure 1 and 2). Tests could be performed both under random and periodic oscillatory flow conditions. LOWST could be used to study sediment transport phenomena and related problems under controlled simulated wave-current boundary-layer conditions at full scale. Basic problems such as boundary-layer flows, bed-load transport, suspended sediment transport, unsteady bed shear-stress, incipient motion and ripple formation, sediment erosion and suspension, liquefaction of cohesive sediments, dynamics of fluid mud, hydrodynamic forcing on marine pipelines, and hydrodynamic control of contaminant fluxes at sediment-water interfaces, could be studied with the help of LOWST. The main interest here, however, is to use this unique facility to study the behavior of model mines, including burial or partial burial, in a shallow- water sedimentary environment for a wide range of full-scale, wave-current conditions and sediment characteristics. The work to be conducted with LOWST will provide important knowledge needed to advance mine burial prediction models.

APPROACH

Strong bottom wave-like, oscillatory flows make it very difficult to measure flow conditions about objects on the seabed, particularly under extreme conditions when most of the scour and mine burial can be expected to take place. Scour around mines depends strongly on the interaction between swift currents, wave action, the geometry and dimensions of the mine, and the properties of the sediment bed. In the laboratory, it is possible to make observations under controlled conditions but the oscillatory flow velocities that can be generated in most experimental facilities are not representative of field conditions. LOWST will be used make detailed observations of scour around and burial of model mines over a movable sediment bed. The main idea in these experiments will be to expose model mines to oscillatory flows over a wide range of flow conditions

Strong collaboration with all the modelers involved in the Mine Burial Prediction Program will be expected. The observations made in LOWST should prove useful for the calibration, validation, and improvement of existing and future mathematical models for mine burial prediction. At the same time, the mathematical models will provide guidance for the laboratory experiments.

WORK COMPLETED

The design of LOWST was completed and the system is currently under construction. It is estimated that LOWST will be ready for preliminary testing in November 2002. Tests have been conducted in a small oscillatory flow facility with the goal of preparing the particle-Image-Velocimetry (PIV) technique that will be used in LOWST to assess burial and scour around mines.

TRANSITIONS

Strong collaboration with all the modelers involved in the Mine Burial Prediction Program will be expected. The observations made in LOWST should prove useful for the calibration, validation, and improvement of existing and future mathematical models for mine burial prediction. At the same time, the mathematical models will provide guidance for the laboratory experiments.

RELATED PROJECTS

Within the Mine Burial Prediction Program there are a number of related projects. In particular, substantial cooperation is expected with Prof. C.C. Mei, MIT, Prof. Harindra Fernando, Arizona State University, Prof. Diane Foster, Ohio State University, and Prof. Patricia Wiberg, University of Virginia. LOWST has also generated substantial interest within the EuroSTRAFORM Program.
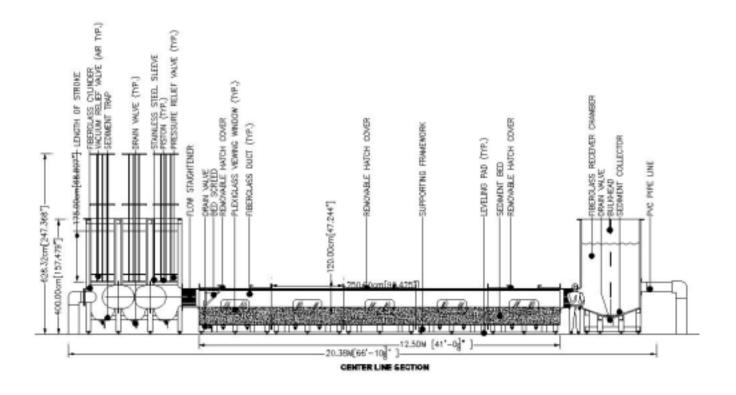
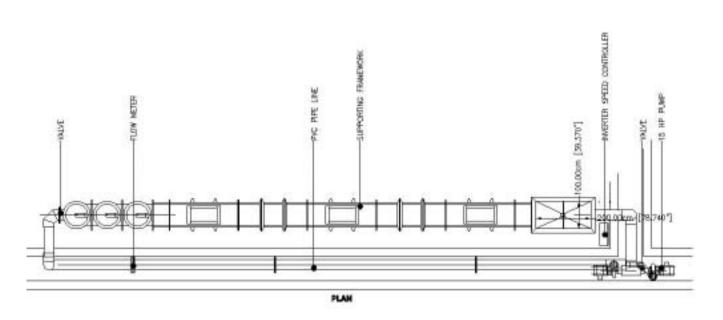*Figure 1. Large Oscillating Water-Sediment Tunnel, LOWST (side view)*

Figure 2. Large Oscillating Water-Sediment Tunnel, LOWST (top view)